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**С. Б. Адиса\*, И. С. Логинова, А. Н. Солонин**

НИТУ МИСиС, Москва, Россия

\*Adisasaheed11@yahoo.com

Научный руководитель – проф., док. техн. наук, А. Н. Солонин.

## ОПТИМИЗАЦИЯ ПАРАМЕТРОВ ЛАЗЕРНОЙ СВАРКИ АЛЮМИНИЕВОГО СПЛАВА 7020

### АННОТАЦИЯ

В работе изучено влияние технологических параметров процесса лазерной сварки на геометрию сварного шва, включая глубину и ширину, а также влияние соотношения различных параметров, например, мощность лазерного пучка и скорость его движения.

*Ключевые слова: лазерная сварка, алюминиевый сплав, структура*

**S. B. Adisa, I. S. Loginova, A. N. Solonin**

## THE OPTIMISATION OF LASER WELDING PROCESS PARAMETERS OF 7020 ALUMINIUM ALLOY

### ABSTRACT

Laser welding has been proven to be promising for the aerospace industry. Welds with high aspect ratio are produced with lower heat input compared with conventional welding is given, combining the trials with Nd:YAG laser and existing knowledge in the referred literature. In this work, we studied the effect of process parameters on weld profile geometry including penetration depth and width on top surfaces and interfaces as well as its quality at different process parameters such as Laser power and speed.

*Keywords: laser welding, alunium alloy, structure*

### INTRODUCTION

In the recent years, the pressure on the automobile industry to reduce fuel consumption and CO<sub>2</sub> emission is on the increase. Therefore, there is need for the use of lightweight materials in the automotive industry.

One of the options for reducing light weight is the replacement of steel by aluminium alloys in automobile industry. The widely used alloys are the medium strength 5xxx (Al-Mg) and 6xxx (Al-Mg-Si) because of their high strength to weight ratio, good formability, weldability and corrosion resistance.

However, there is limited use of 7xxx (Al-Zn) series despite its higher specific strength compared to the above alloys because of it has weldability problems like hot cracking and porosity in the weld.

Laser welding is a promising technology in the industry because of the possibility of joining and repairing different materials. It has some setbacks in comparison with other conventional joining technologies such as the high costs of equipment, sample alignment and strict requirements concerning the laser beam adjustment. However, laser welding shows important advantages compared with other techniques such as the little heat input, better flexibility, high welding speed, better weld quality and high production rate.

Age hardened Al-Zn-Mg-Cu alloys are generally named 7xxx and it is commonly used in the aerospace, high speed trains, automotive industries because of their attractive properties, especially their high specific strength. Currently, they are connected by mechanical fastening methods while the laser beam welding has been used to join 5xxx series aluminium alloys which reduces simultaneously the weight and production cost.

The laser welding is generally more difficult to apply to aluminium alloys than to steel alloys, due to its higher reflectivity, higher thermal conductivity and lower viscosity. The high reflectivity makes the aluminium alloys absorb low fraction of the incident radiation; the high thermal conductivity provokes a rapid heat transfer, avoiding the concentration of energy in the weld pool; and finally, the lower viscosity of the welding pool limits the expansion of the pool before the solidification. Secondly, it causes inconsistent penetration and weld pool instability. Therefore an optimization of the process parameters is needed to minimize this weldability problems and other defects so that laser welding will be highly desirable for the production of high strength to weight ratio components especially for transport equipment purposes.

The material used is AA7020 aluminium alloy. The alloy with dimension 66\*36\*19mm was casted which was later cold rolled to give a thickness of 1mm. It was cut into standard dimension for analysis.

Composition of Aluminium alloy 7020, mass %: Al-92, Cu-0,3, Cr- 0,2, Fe-0,3, Mg -1,2, Mn-0,5, Si-0,3 , Ti-0,05, Zn- 5, Zr-0,2.

Preweld cleaning requires two operations which are oil, grease and oxide removal. The sample is first cleaned with HNO<sub>3</sub> and washed off by water and later cleaned by NaOH which is also followed by rinsing with water, the alternative to this is the use of acetone. This operation is to remove oxide so as to allow the penetration of laser light.

The laser welding machine model used is MUL-1N200 pulse periodic action. It was solid state Nd:YAG laser which operates on a wavelength of 1064 nm.

The pulse duration is changed in the range of 0,4 to 20 ms, pulse repetition frequency of 0,5 Hz to 20 Hz, the power rating is 1Kw, the speed of movement of the stage varies from 0,25 to 20 m/s, the shielding gas is argon.

Before welding, the water was opened to cool the system and the argon gas was opened to the pressure of 12 Mpa to prevent oxidation. The aluminium alloy was fixed on the vice with the aid of a leveler and zoom the binocular along the vertical until a clearer vision was obtained. The shield gas hose was placed very close to the sample to protect it from oxidation and also laser exposure. The sample was welded at various process parameters. The cross section of the sample was prepared for analysis.

The first step is pressing the welded sample into plastic with the use of acetone (CH<sub>3</sub>)<sub>2</sub>Co and polystyrene. After waiting for some hours to allow the molded sample to get dried, the sample was grinded with emery papers of different sizes to remove scratches and it was further polished on Struers using emery papers of size 2000 and 4000micron respectively to produce a shiny surface.

After polishing the sample, it was removed from the plastic and then etched at a voltage of 20 V using lead as the cathode and the sample the anode. The Cathode is placed inside the electrolyte which contains (6 parts of ethanol, 1part of HClO<sub>4</sub> and 1part of glycerine) while the anode is the clip holding the sample. The sample is immersed in the electrolyte for 10 sec, the sample was then rinse in water after that, it was cleaned with absorbing paper. This process was repeated three times so as to obtain a clearer microstructure from the light microscope. The etched sample was later analysed using the light microscope and picture of the weld from different regime were obtained. This sample pictures obtained was later finally analysed using the sizer to get the depth and width of the weld.

Experimental conditions:

Constants: Voltage is 400V, Duration is 5ms, Diameter of beam is standard,

Overlap is 0,1mm

Vary parameter: Velocity: 0,25, 0,5, 1, 2, 3, 4, 5, 6 and 7 mm/s

Table

The width and depth of the laser welded joint

Regime(velocity,mm/s)	Depth(μm)	Width(μm)
0,25	173,90	803,70
0,5	196,00	816,00
1	200,40	820,90
2	228,30	826,40

3	216,00	834,30
4	251,40	949,90
5	246,80	944,60
6	242,70	951,40
7	250,90	985,40

The quality of the weld in this case is higher at lower welding velocity because the depth of penetration relative to the width of weld is higher compare to those in the higher velocity region.

The pictures shown in fig.2 below is the microstructure of the weld cross section after etching showing the depth of penetration and width of the butt joint. It also shows the grain structure at different stages of solidification. It is also observed that the microstructure of the base metal is different from that of the fusion zone, the external zones of the bead close to the base metal are characterised by showing a dendritic growth.

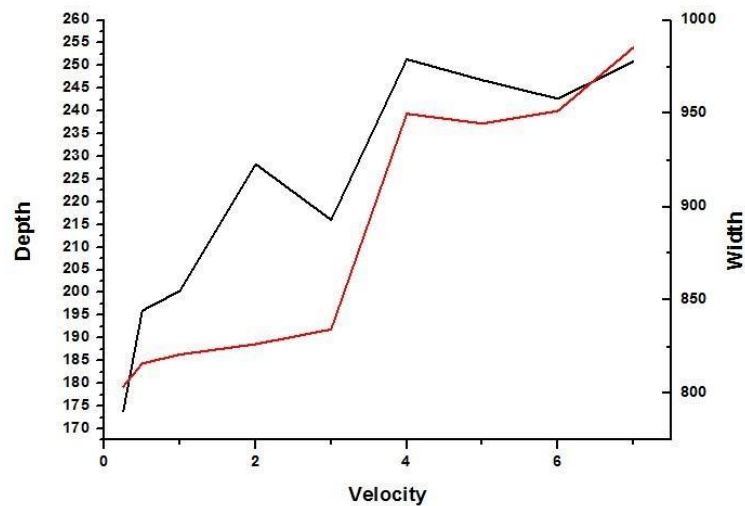


Fig. 1. Weld Velocity, Penetration and Depth

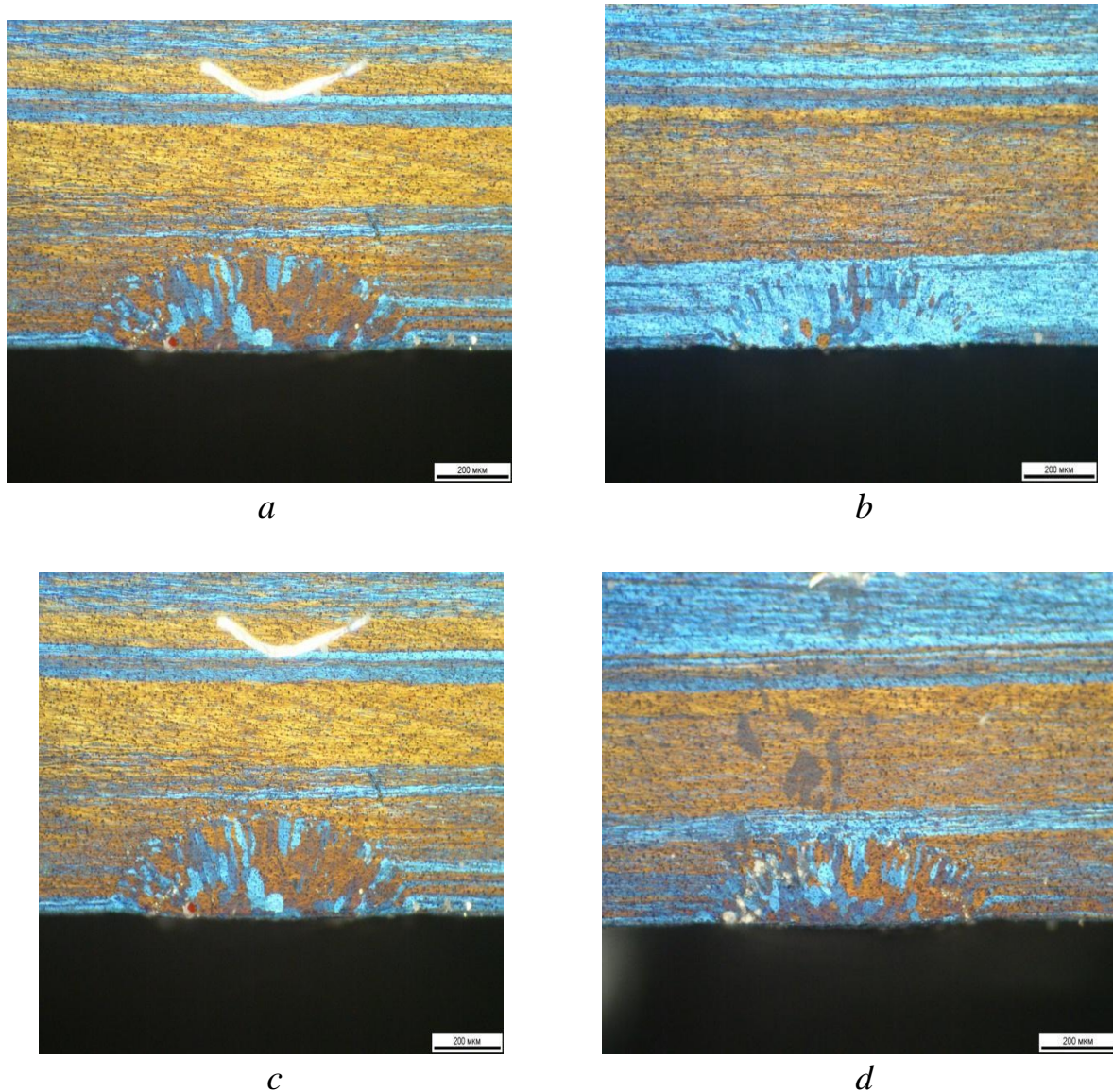


Fig. 2. The Microstructure of the weld cross section after etching showing the depth of penetration of the butt joint

In the experiment it is obvious that the quality of the weld in this case is higher at lower welding velocity preferably at 2mm/s because the depth of penetration relative to the width of weld is higher compare to those in the higher velocity region. Welding at lower velocity reduce the tendency of transverse solidification cracking so in the future it is advisable to investigate in this region of velocity to achieve an efficient weld.

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